(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 270 868 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
02.01.2003 Bulletin 2003/01

(51) Int Cl.7: E21B 10/26, E21B 10/42, E21B 7/06

(21) Application number: 02014475.4

(22) Date of filing: 26.10.2000

(84) Designated Contracting States:
BE DE FR IE IT

(30) Priority: 28.10.1999 US 162179
03.11.1999 US 163420

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
00309435.6 / 1 096 103

(71) Applicant: Camco International (UK) Limited
Stonehouse, Gloucestershire GL10 3RQ (GB)

(72) Inventors:
- Watson, Graham R.
Gloucestershire GL2 2EY (GB)
- Hart, Steven James
Bath, Avon BA1 2TE (GB)

(74) Representative: Bailey, Richard Alan
A.R. Davies & Co.,
27 Imperial Square
Cheltenham, Gloucestershire GL50 1RQ (GB)

Remarks:
This application was filed on 29 - 06 - 2002 as a divisional application to the application mentioned under INID code 62.

(54) A bi-centre bit for drilling out through a casing shoe

(57) The present invention is a bi-center drill bit designed to drill out the cement and other material in the casing and then proceed to drill out the full gauge drilling diameter borehole with a diameter greater than the inside of the casing. The bi-center drill bit is configured with non-drilling bearing elements (68,168) that contact with the casing when the bit is drilling the cement without allowing the gauge cutting elements (24,124) of the bi-center drill bit to contact the casing. The bi-center drill bit also has a cutting element configuration which prevents reverse scraping of the cutting elements when drilling both the cement and the formation.

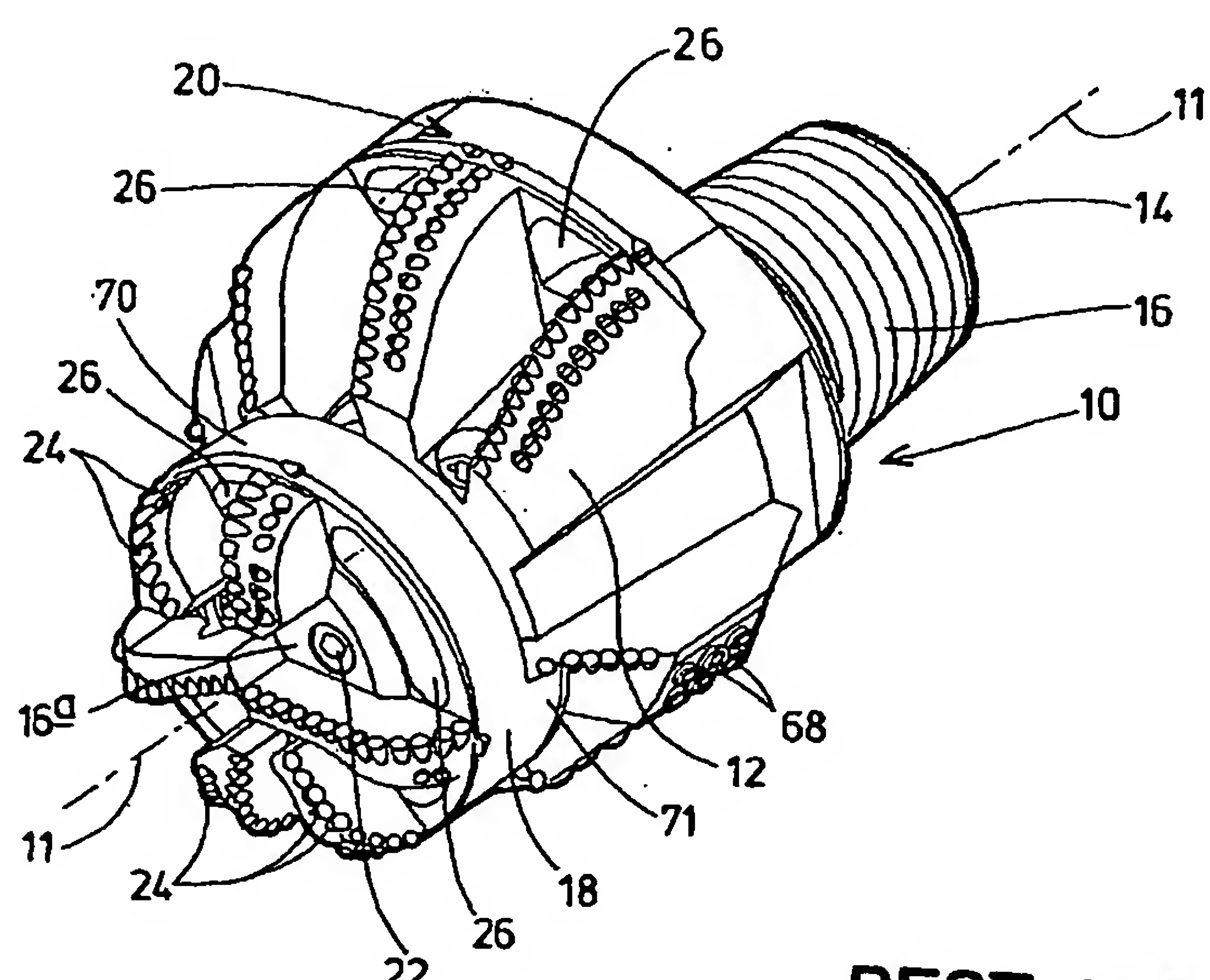

FIG 1

BEST AVAILABLE COPY

Printed by Jouve, 75001 PARIS (FR)

Description

[0001] This invention relates to bits used for drilling boreholes into the earth for mineral recovery. In particular, the present invention is a bi-center drill bit that can drill a borehole in the earth with a diameter greater than that of the drill bit, and also drill out the cement and float shoe after the casing has been cemented in place.

[0002] In the pursuit of drilling boreholes into the earth for the recovery of minerals, there are instances when it is desirable to drill a borehole with a diameter larger than the bit itself. Drill bits used to form these boreholes are generally known as bi-center type drill bits.

[0003] Bi-center drill bits are well known in the drilling industry. Various types of bi-center drill bits are described in U.S. Patents Nos. 1,587,266, 1,758,773, 2,074,951, 2,953,354, 3,367,430, 4,408,669, 4,440,244, 4,635,738, 5,040,621, 5,052,503, 5,165,494, 5,678,644 and European Patent Application 0,058,061 all herein incorporated by reference.

[0004] Modem bi-center drill bits are typically used in difficult drilling applications where the earth formations are badly fractured, where there is hole swelling, where the borehole has a tendency to become spiraled, or in other situations where an oversize hole is desirable.

[0005] In these difficult drilling applications, the top portion of the well bore is often stabilized by setting and cementing casing. The cement, shoe, float, and related cementing hardware are then typically drilled out of the casing by a drill bit that is run into the casing for this purpose. Once the cement and related hardware are drilled out, the drill-out bit is tripped out of the hole and a bi-center drill bit is run back in. Drilling then proceeds with the bi-center drill bit, which drills a hole into the formation below the casing with a diameter that is greater than the inside diameter of the casing.

[0006] To reduce drilling expenses, attempts have been made to drill the cement and related hardware out of the casing, and then drill the formation below the casing with a single bi-center drill bit. These attempts often resulted in heavy damage to both the casing and the bi-center drill bit.

[0007] The casing tends to be damaged by the gauge cutting elements mounted on the bi-center drill bit because inside the casing the pilot section of the bit is forced to orbit about its center, causing the gauge cutters to engage the casing. The forced orbiting action of the pilot section also causes damage to the cutters on the leading face of the bi-center drill bit.

[0008] The degree of damage to both the casing and the bit is further increased when a directional drilling bottom hole assembly is attached to the drill string just above the bit. It is often desirable to directionally drill the borehole beneath the casing with directional drilling systems utilizing bent subs. When the bi-center drill bit drills the cement and related hardware out of the casing with a bent sub directional system, the side forces caused by the forced orbiting action of the bi-center drill bit are additive with the side forces caused by rotating with a bent sub. The resulting complex, and excessive forces have caused failures in bi-center drill bits in as few as three feet of drilling. The same problems occur with related directional drilling systems that force the bi-center drill bits along paths other than their centerlines.

[0009] The present invention is a bi-center drill bit designed to drill out the cement and other material in the casing and then proceed to drill out the full gauge drilling diameter borehole with a diameter greater than the inside of the casing. The bi-center drill bit is configured with non-drilling bearing elements that contact with the casing when the bit is drilling the cement without allowing the gauge cutting elements of the bi-center drill bit to contact the casing. The bi-center drill bit also has a cutting element configuration which prevents reverse scraping of the cutting elements when drilling both the cement and the formation.

[0010] Disclosed is a bi-center drill bit with a bit body with a first end adapted to be detachably secured to a drill string, a pilot section on a second, opposite end of the bit body and a reamer section intermediate the first and second ends. There are a plurality of cutting elements on the pilot section, a first center of rotation of the pilot section, and a first cutting face surface on the pilot section generated by the plurality of cutting elements as they are rotated about the first center of rotation of the pilot section. There is a second center of rotation of the pilot section spaced apart from the first center of rotation by a distance D with a second cutting face surface on the pilot section generated by the plurality of cutting elements as they are rotated about the second center of rotation of the pilot section. There is also a first region of the pilot section centered about the first center of rotation having a radius D, a second region of the pilot section centered about the second center of rotation having a radius D and a third region of the pilot section formed by the intersection of the first region and the second region. There are no cutting elements lying within the third region of the pilot section that contact both the first cutting face surface and the second cutting face surface.

[0011] Also disclosed is a bi-center drill bit with a bit body, the bit body having a longitudinal axis, a first end adapted to be detachably secured to a drill string, a pilot section on a second, opposite end of the bit body and an eccentric reamer section intermediate the first and second ends. There are a plurality of cutting elements on the pilot section, a first center of rotation of the pilot section about the longitudinal axis, and a radius of rotation R1 of the drill bit about the first center of rotation. There is a second center of rotation of the pilot section spaced apart from the first center of rotation by a distance D and a radius of rotation R2 of the drill bit about the second center of rotation. The radius of rotation R1 is less than the sum of the radius of rotation R2 and D.

[0012] Also disclosed is a bi-center drill bit with a bit body, the bit body having a longitudinal axis, a first end

adapted to be detachably secured to a drill string, a pilot section on a second, opposite end of the bit body and an eccentric reamer section intermediate the first and second ends. There are a plurality of cutting elements on the pilot section, a first center of rotation of the pilot section about the longitudinal axis, and a radius of rotation R1 of the drill bit about the first center of rotation. There is a second center of rotation of the pilot section spaced apart from the first center of rotation by a distance D, and a radius of rotation R2 of the drill bit about the second center of rotation. The radius of rotation R1 is less than the sum of the radius of rotation R2 and D and a plurality of non-cutting bearing elements are mounted upon the bit body at radius R2.

[0013] Also disclosed is a bi-center drill bit with a bit body, the bit body having a longitudinal axis, a first end adapted to be detachably secured to a drill string, a pilot section on a second, opposite end of the bit body and an eccentric reamer section intermediate the first and second ends. There are a plurality of cutting elements on the pilot section, a first center of rotation of the pilot section about the longitudinal axis, and a radius of rotation R1 of the drill bit about the first center of rotation. There is a second center of rotation of the pilot section spaced apart from the first center of rotation by a distance D and a radius of rotation R2 of the drill bit about the second center of rotation. The radius of rotation R1 is less than the sum of the radius of rotation R2 and D and a plurality of gauge cutting elements are mounted upon the bit body at radius R1.

[0014] Also disclosed is a bi-center drill bit with a bit body, the bit body having a longitudinal axis, a first end adapted to be detachably secured to a drill string, a pilot section on a second, opposite end of the bit body and an eccentric reamer section intermediate the first and second ends. There are a plurality of cutting elements on the pilot section, a first center of rotation of the pilot section about the longitudinal axis, and a radius of rotation R1 of the drill bit about the first center of rotation. There is a second center of rotation of the pilot section spaced apart from the first center of rotation by a distance D and a radius of rotation R2 of the drill bit about the second center of rotation. The radius of rotation R1 is less than the sum of the radius of rotation R2 and D and a plurality of non-cutting bearing elements are mounted upon the bit body at radius R2 and a plurality of gauge cutting elements are mounted upon the bit body at radius R1.

[0015] Also disclosed is a bi-center drill bit with a bit body with a first end adapted to be detachably secured to a drill string, a pilot section on a second, opposite end of the bit body and a reamer section intermediate the first and second ends. There are a plurality of cutting elements on the pilot section, a first center of rotation of the pilot section and a second center of rotation of the pilot section spaced apart from the first center of rotation by a distance D. There is a first region of the pilot section centered about the first center of rotation having a radius D, a second region of the pilot section centered about the second center of rotation having a radius D, and a third region of the pilot section formed by the intersection of the first region and the second region. The third region of the pilot section is devoid of cutting elements.

[0016] Also disclosed is a bi-center drill bit with a bit body, the bit body having a longitudinal axis, a first end adapted to be detachably secured to a bent sub directional drill tool, a pilot section on a second, opposite end of the bit body and a reamer section intermediate the first and second ends. The outer portion of the pilot section is an uninterrupted circular section.

[0017] The invention will further be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a bi-center drill bit of the present invention.

Figure 2A is a side view of a bi-center drill bit of the present invention.

Figure 2B is a side view of a bi-center drill bit of the present invention shown drilling the cement within the casing set in a borehole in the earth.

Figure 2C is a side view of a bi-center drill bit of the present invention shown drilling a full gauge borehole in an earth formation below a smaller diameter casing.

Figure 3 is an end view of a bi-center drill bit of the present invention.

Figure 4 is an enlarged view of a portion of the bi-center drill bit of Figure 3.

Figure 5 is another enlarged view of a portion of the bi-center drill bit of Figure 3.

Figure 6A is an end view of a bi-center drill bit of the present invention showing certain relationships.

Figure 6B is view of the first cutting surface generated by the cutters of the bi-center drill bit of Figure 6A.

Figure 6C is view of the second cutting surface generated by the cutter of the bi-center drill bit of Figure 6A.

Figure 7 is a side view of an alternate preferred embodiment of the bi-center drill bit of the present invention.

Figure 8 is a side view of the alternate preferred embodiment of the bi-center drill bit shown in Figure 8.

Figure 9 is another alternate preferred embodiment of a bi-center drill bit of the present invention for use with a bent sub directional drill tool.

[0018] As shown in Figures 1 and 2A, the bi-center drill bit 10 of the present invention has a longitudinal axis 11, a bit body 12 with a first end 14 which is adapted to be secured to a drill string (not shown). Typically, threads 16 are used for attachment to the drill string, but other forms of attachment may also be utilized. At the second, opposite end 16a of the bit body 12 is the pilot section 18 of the bi-center drill bit 10. A reamer section, shown generally by numeral 20, is intermediate the first end 14 and the pilot section 18 of the bi-center drill bit 10.

[0019] During operation, the bit body 12 is rotated by an external means while the bi-center drill bit 10 is forced into the material being drilled. The rotation under load causes cutting elements 24 to penetrate into the drilled material and remove the material in a scraping and/or gouging action.

[0020] The bit body 12 has internal passaging (not shown) which allows pressurized drilling fluid to be supplied from the surface to a plurality of nozzle orifices 22. These nozzle orifices 22 discharge the drilling fluid to clean and cool the cutting elements 24 as they engage the material being drilled. The drilling fluid also transports the drilled material to the surface for disposal.

[0021] In one preferred embodiment the pilot section 18 has an uninterrupted circular section 70 with at least one fluid passage 26 provided for return flow of the drilling fluid. The uninterrupted circular section 70 will be described in greater detail later in the specification. There also may be other fluid passages 26 provided in the reamer section 20 of the bi-center drill bit 10.

[0022] Referring now to Figures 2B and 2C, shown are side views of a bi-center drill bit 10 of the present invention. One important characteristic of the bi-center drill bit 10 is its ability to drill a borehole 11 into the earth 13 with a gauge drilling diameter larger than the inside diameter of the casing 15, or pipe or other type of conductor the bit 10 must pass through. This characteristic is shown in Figure 2C.

[0023] Another important characteristic of the of the bi-center drill bit 10 is its ability to drill out the cement 17 (and related hardware, not shown) inside the casing 15 as shown in Figure 2B without causing damage to the casing 15 or the cutting elements 24.

[0024] Referring now to Figure 3, shown is an end view of a bi-center drill bit 10 of the present invention. The gauge drilling diameter, as indicated by the circle 28, is generated by radius R1 from a first center of rotation 30 of the pilot section 18. In this drilling mode, the uninterrupted circular section 70 of the pilot section will be concentric with the diameter 28. The cutting elements 24 on the portion of the reamer section 20 radially furthest from the first center of rotation 30 actually drill the gauge drilling diameter of the borehole 11, as indicated at numeral 31. The reamer section 20 is formed eccentrically of the pilot section 18, so only a portion of the wall of the borehole 11 is in contact with the cutting elements 24 which cut the final gauge of the borehole at any given time during operation.

[0025] The bi-center drill bit 10 also has a pass through diameter, as indicated by the circle 32, generated by radius R2 from a second center of rotation 34 of the pilot section 18. The shortest linear distance between the centers of rotation 30, 34 is indicated as D. The second center of rotation 34 is on the centerline of the smallest cylinder that can be fitted about the bi-center drill bit 10. To be effective, the pass through diameter as indicated by circle 32 must be smaller than the inside diameter of the casing 15 the bi-center drill bit 10 must pass through.

[0026] For optimal life, the cutting elements 24 must be oriented on the pilot section 18 in a known manner with respect to the direction of scraping through the material being drilled. This is no problem for bi-center drill bits that do not drill the cement and related hardware out of the casing. However, when a bi-center drill bit is used to drill cement and related hardware in the casing, some of the cutting elements 24 may be subjected to reverse scraping while rotating about the second center of rotation 34. Reverse scraping often causes rapid degradation of the cutting elements 24, and must be avoided.

[0027] For the embodiment of the invention shown in Figures 1 - 5, 6A, 6B, 6C, and 9 the cutting elements 24 are polycrystalline diamond compact cutters or PDC. A PDC is typically comprised of a facing table of diamond or other superhard substance bonded to a less hard substrate material, typically formed of but not limited to, tungsten carbide. The PDC is then often attached by a method known as long substrate bonding to a post or cylinder for insertion into the bit body 12. This PDC type of cutting element 24 is particularly sensitive to reverse scraping because loading from reverse scraping can easily destroy both the diamond table bonding and the long substrate bonding.

[0028] Shown in Figures 4 and 5 are the paths of cutting elements 24 on the pilot section 18 of the bi-center drill bit 10 as they are rotated about each center of rotation 30, 34. In Figure 4 the cutting elements 24 on the pilot section 18 are rotated about the second center of rotation 34. The bi-center drill bit 10 rotates about the second center of rotation 34 when it is drilling the material inside the casing 15 as shown in Figure 2B. Directional arrows 52 are displayed for many of the cutting elements 24. The directional arrows 52 show the paths of the cutting elements 24 relative to the material being drilled as the bi-center drill bit 10 is rotated about the second center of rotation 34. As is apparent, none of the cutting elements 24 are subject to reverse scraping.

[0029] In Figure 5 the cutting elements 24 are rotated about the first center of rotation 30. The pilot section 18 on bi-center drill bit 10 rotates about the first center of rotation 30 when the bit is drilling a borehole 11 beneath

the casing 15 as shown in Figure 2C. Directional arrows 54 are displayed for many of the cutting elements 24. The directional arrows 54 show the paths of the cutting elements 24 relative to the material being drilled as the pilot section 18 on bi-center drill bit 10 is rotated about the first center of rotation 30. As is again apparent, none of the cutting elements 24 are subject to reverse scraping.

[0030] Figures 6A, 6B, and 6C represent how the arrangement of the cutting elements 24 can be characterized in order to prevent reverse scraping. As stated earlier, the distance D is the shortest linear distance between center of rotation 30 and center of rotation 32. A first region 56 of the pilot section 18 centered about the first center of rotation 30 has a radius D. A second region 58 of the pilot section 18 centered about the second center of rotation 34, and also has a radius D. A third region 60 of the pilot section 18 is formed by the intersection of the first region 56 and the second region 58. This iris shaped third region 60 is the critical area where reverse cutter scraping is possible.

[0031] A first cutting face surface on the pilot section is illustrated in Figure 6B with numeral 62, and a second cutting face surface on the pilot section is illustrated in Figure 6C with numeral 66. A cutting face surface 62, 66 is the hypothetical surface generated by the tips of the cutting elements 24 as they are rotated about one of the centers of rotation 30, 34.

[0032] By way of example, the first cutting face surface 62 as generated has the same shape as the surface of the bottom of the hole drilled by the pilot section 18 of the bi-center drill bit 10. However, because the cutting elements 24 penetrate into the formation 13 a small distance to create the first cutting face surface 62, the surface 62 will be positioned on the pilot section intermediate the tips of the cutting elements 24 and the body of the pilot section 18. The cutting face surface of the reamer section 20 is shown as numeral 64.

[0033] In one embodiment of the bi-center drill bit 18 of the present invention the third region 60 on the pilot section 18 is devoid of cutting elements 24, as shown in Figures 1-6C and 9. This assures that none of the cutting elements 24 will experience reverse cutter scraping.

[0034] Shown in Figures 7 and 8 is an alternate design bi-center drill bit 110. The bi-center drill bit 110 illustrated is an infiltrated type bi-center drill bit. The bi-center drill bit 110 has a longitudinal axis 111, a bit body 112 with a first end 114 which is adapted to be secured to a drill string (not shown). Typically, threads 116 are used for attachment to the drill string, but other forms of attachment may also be utilized. At the second, opposite end 116a of the bit body 112 is the pilot section 118 of the bi-center drill bit 110. A reamer section shown generally by numeral 120 is intermediate the first end 114 and the pilot section 118 of the bi-center drill bit 110.

[0035] Cutting elements 124 in an infiltrated bit are typically natural or synthetic diamond or other superhard particles that are arranged upon the surface. In one type of infiltrated bit, the cutting elements 124 are fairly large natural diamonds (greater about than .5 carat) partially exposed at the surface. In another type of infiltrated bit, the cutting elements 124 are much smaller diamond or diamond-like particles impregnated within the matrix to a significant depth.

[0036] During operation, the bit body 112 is rotated by some external means while the bi-center drill bit 110 is forced into the material being drilled. The rotation under load causes cutting elements 124 to penetrate into the drilled material and remove the material in a scraping and/or gouging action.

[0037] The bit body 112 has internal passaging (not shown) which allows pressurized drilling fluid to be supplied from the surface to a plurality of orifices 122. These orifices 122 discharge the drilling fluid to clean and cool the cutting elements 124 as they engage the material being drilled. The drilling fluid also transports the drilled material to the surface for disposal. The other elements of the bi-center drill bit 110 similar to the bi-center drill bit 10 are indicated by numerals increased by 100.

[0038] In the bi-center drill bit 110 shown in Figures 7 and 8, it may be desirable to place some of the cutting elements 124 in the third region 160 of the pilot section. As it is still desirable not to subject cutting elements 124 to reverse scraping, they may be oriented such that they contact one of the cutting face surfaces 62, 66 when operating in that drilling mode, and yet be of a different height with respect to the body 112 such that they are intermediate the other cutting face surface and the body of the pilot section 118 when operating in the other drilling mode. In this arrangement, none of the cutting elements 24, 124 lying within the third region 60, 160 contact both the first cutting face surface 62 and the second cutting face surface 66.

[0039] In another aspect of the preferred embodiment of the bi-center drill bit 10, 110 of the present invention, a relationship is established among R1, R2, and D which allows a design of the bi-center drill bit 10, 110 to drill the cement and related hardware out of the casing without the risk of damaging the casing 15.

[0040] When the radius of rotation R1 about the first center of rotation is less than the sum of the radius of rotation R2 about the second center of rotation and D, the gauge cutting elements 31 cannot contact the casing 15 as the bi-center drill bit 10, 110 is operated in or passed through the casing 15. This is shown as a gap between circle 28 and circle 32 at the location of gauge cutting elements 31, 131.

[0041] A bi-center drill bit made with the relationship of $R1<R2+D$ will assure that the casing 15 will not be damaged by the gauge cutting elements 31, 131.

[0042] The bi-center drill bit 10 of Figures 1-3 has a plurality of blades 36, 38, 40, 42, 44, 46, 48, 50. A plurality of non-cutting bearing elements 68 are mounted upon the blades 38, 40, 42, 44, 46, 48, 50 to set the pass through diameter, as indicated by the circle 32.

[0043] These non-cutting bearing elements 68 are spaced around the arc of the circle 32 at a maximum spacing angle less than 180 degrees. When the non-cutting bearing elements 68 are placed in this manner the casing 15 is further protected from wear by the blades 38, 40, 42, 44, 46, 48, 50.

[0044] Referring now to Figures 7 and 8, in a similar manner, non-cutting bearing elements 168 are spaced on the infiltrated bi-center drill bit 110 to prevent the gauge 131 cutting elements 124 from damaging the casing 15 and/or cause damage to the gauge cutting elements 131.

[0045] There are many suitable forms of non-cutting bearing elements 68, 168. For example, the bearing elements 68, 168 may simply be the ends of one or more of the blades 38, 40, 42, 44, 46, 48, 50. It is possible to join one or more of these blades with a continuous ring or other structure connecting the blades to form an elongated bearing with greater contact. It is also possible to make the ring or structure of a smaller radius than R2, and place a plurality of individual non-cutting bearing elements 68, 168 along the ring or structure with enough protrusion to form the radius R2, as shown.

[0046] Non-cutting bearing elements 68, 168 may be in the form of flush type or protruding PDC, tungsten carbide, or other hard material inserts. The non-cutting bearing elements 68, 168 may also be in the form of a flame spray coating containing one or more hard, wear resistant materials such as carbides of tungsten, titanium, iron, chromium, or the like. It is also possible to apply a diamond-like-carbon material to act as a non-cutting bearing element 68, 168.

[0047] In addition to placing the non-cutting bearing elements 68, 168 along the blades 38, 40, 42, 44, 46, 48, 50, they may also be optionally be placed in the uninterrupted circular section 70 of the pilot section 18. In the uninterrupted circular section 70, the non-cutting bearing elements 68 help reduce the wear on the uninterrupted circular section 70 caused as the reaction force of the stabilizer section 20 pushes the uninterrupted circular section 70 into the formation 13.

[0048] Because the non-cutting bearing elements 68 are placed along the radius R2, it is possible to put both non-cutting bearing elements 68 and gauge cutting elements 31 on the same blade 38. Blade 38 is shaped such that the non-cutting bearing elements 68 are on a surface that has been relieved away from radius R1 to permit mounting of the non-cutting bearing elements 68. Preferably, this relieved surface will be concentric with radius R2. The result is that blade 38 will have surfaces with two radii, one surface concentric with radius R2 and a second surface concentric with radius R1.

[0049] Although this is shown on only one blade 38 in Figure 3, it is possible to have the non-cutting bearing elements 68 and the gauge cutting elements 31 on a second blade if the blade is positioned adjacent to one of the intersections of R1 and R2 as indicated by numeral 39. Placing the non-cutting bearing elements 68 on a blade in this manner provides the maximum stability for the bi-center drill bit as it drills the cement 17 from the casing 15.

[0050] In the bi-center drill bit of Figures 1-6C, the pilot section 18 may have an uninterrupted circular section 70. The uninterrupted circular section 70 acts to stabilize the pilot section 70 when the bi-center drill bit 10 is drilling the gauge drilling diameter in the formation 13. As previously described, the uninterrupted circular section 70 also acts as a bearing against the formation 13 to resist the side forces generated by the reamer section 20 as it drills the gauge diameter of the borehole 11. An additional bearing section 71 (shown in Figure 1) may be provided on the uninterrupted circular section 70. This additional bearing section 71 adds additional bearing surface area to further reduce the unit loading and minimize wear of the side of the uninterrupted circular section 70 opposite from the reamer section 20.

[0051] Shown in Figure 9 is a bi-center drill bit 210 configured in a very similar manner to the bi-center drill bit 10, 110 of Figures 1-8. For brevity of description, elements of the bi-center drill bit 210 with characteristics similar to the bi-center drill bit 10 are indicated with numerals increased by 200.

[0052] In Figure 9, the uninterrupted circular section 270 on the pilot section 218 also provides a secondary bearing surface when the bi-center drill bit is driven by a bent sub type directional drill tool 72. In addition, the uninterrupted circular section 270 is provided with a curved end 78, generated by radius 74, and a curved profile 80 for the non-cutting bearing elements 268, generated by radius 76. The curved end 78 and curved profile 80 act to prevent the comers of the uninterrupted circular section 270, and the non-cutting bearing elements 268 from damaging the casing 215.

[0053] Whereas the present invention has been described in particular relation to the drawings attached hereto, it should be understood that other and further modifications apart from those shown or suggested herein, may be made within the scope and spirit of the present invention.

Claims

1. A bi-center drill bit comprising a bit body (12,112), the bit body (12,112) having a longitudinal axis (11,111), a first end (14,114) adapted to be detachably secured to a drill string, a pilot section (18,118) on a second, opposite end (16a,116a) of the bit body (12,112) and an eccentric reamer section (20,120) intermediate the first and second ends (14,16a,114,116a), and
a plurality of cutting elements (24,124) on the pilot section (18,118),
a first center of rotation (30,130) of the pilot section (18,118) about the longitudinal axis (11,111),
a radius of rotation R1 of the drill bit about the first

center of rotation (30,130),
a second center of rotation (34,134) of the pilot section (18,118) spaced apart from the first center of rotation (30,130) by a distance D,
a radius of rotation R2 of the drill bit about the second center of rotation (34,134),
wherein the radius of rotation R1 is less than the sum of the radius of rotation R2 and distance D.

2. A bi-center drill bit comprising a bit body (12,112) with a first end (14,114) adapted to be detachably secured to a drill string, a pilot section (18,118) on a second, opposite end (16a,116a) of the bit body (12,112) and a reamer section (20,120) intermediate the first and second ends (14,16a,114,116a),
a plurality of cutting elements (24,124) on the pilot section (18,118),
a first center of rotation (30,130) of the pilot section (18,118),
a second center of rotation (34,134) of the pilot section (18,118) spaced apart from the first center of rotation (30,130) by a distance D,
a first region (56,156) of the pilot section (18,118) centered about the first center of rotation (30,130) having a radius D,
a second region (58,158) of the pilot section (18,118) centered about the second center of rotation (34,134) having a radius D,
and a third region (60,160) of the pilot section (18,118) formed by the intersection of the first region and the second region,
wherein the third region of the pilot section (18,118) is devoid of cutting elements (24,124).

3. The bi-center drill bit of any Claims 1 and 2 wherein the cutting elements (24,124) of the pilot section (18,118) are arranged upon a plurality of blades formed on the bit body (12,112).

4. The bi-center drill bit of Claim 3, wherein the blades terminate with the cutting elements (24,124).

5. The bi-center drill bit of any of the preceding claims, wherein the cutting elements (24,124) of the pilot section (18,118) are gauge cutting cutter elements.

6. The bi-center drill bit of any of the preceding claims, wherein cutters (24,124) extend to the radius R1.

7. The bi-center drill bit of any of the preceding claims, wherein the cutting elements (24,124) of the pilot section (18,118) are formed of a superhard material.

8. The bi-center drill bit of Claim 7, wherein the superhard material is a preform element with a facing table of diamond bonded to a less hard substrate material.

9. The bi-center drill bit of Claim 8, wherein the facing table of diamond comprises polycrystalline diamond.

10. The bi-center drill bit of Claim 7, wherein the superhard material is natural diamond.

11. The bi-center drill bit of any of the preceding claims, wherein a plurality of non-cutting bearing elements (68,168) are mounted on the bit body (12,112) at radius R2.

12. The bi-center drill bit of Claim 11, further comprising at least two blades extending from the bit body (12,112) and wherein at least one non-cutting bearing element (68,168) is mounted on each blade, each blade terminating with the non-cutting bearing element (68,168).

13. The bi-center drill bit of Claim 12, wherein a maximum included angle about the second center of rotation between the non-cutting bearing elements (68,168) on two adjacent blades is less than 180 degrees.

14. The bi-center drill bit of Claim 12, wherein the non-cutting bearing elements (68,168) are in the form of a flush mounted, hard, wear resistant material.

15. The bi-center drill bit of Claim 14, wherein the non-cutting bearing elements (68,168) are in the form of a flame spray coating containing the carbides of elements selected from the group consisting of tungsten, titanium, iron, and chromium.

16. The bi-center drill bit of Claim 15, wherein the coating is generally uniformly applied over a portion of the at least two blades.

17. The bi-center drill bit of Claim 12, wherein the non-cutting bearing elements (68,168) are in the form of a protruding insert made of a hard, wear resistant material.

18. The bi-center drill bit of Claim 17, wherein the hard, wear resistant material is cemented tungsten carbide.

19. The bi-center drill bit of Claim 18, wherein the hard, wear resistant material is a preform element with a facing table of diamond bonded to a less hard substrate material.

20. The bi-center drill bit of any of the preceding claims, wherein at least one blade is located at the intersection of radius of rotation R1 and the radius of rotation R2.

21. The bi-center drill bit of Claim 20, wherein the blade located at the intersection of radius of rotation R1 and the radius of rotation R2 has at least one non-cutting bearing element (68,168) mounted thereon, the non-cutting bearing element (68,168) extending to the radius of rotation R2.

22. The bi-center drill bit of any one of the preceding claims, further comprising a first region (56,156) of the pilot section (18,118) centered about the first center of rotation (30,130) having a radius D,
a second region (58,158) of the pilot section (18,118) centered about the second center of rotation (34,134) having a radius D,
and a third region (60,160) of the pilot section (18,118) formed by the intersection of the first region (56,156)and the second region (58,158),
wherein the third region of the pilot section is devoid of cutting elements (24,124).

23. A bi-center drill bit comprising a bit body (12,112), the bit body (12,112) having a longitudinal axis (11,111), a first end (14,114) adapted to be detachably secured to a bent sub directional drill tool, a pilot section (18,118) on a second, opposite end (16a,116a) of the bit body (12,112) and a reamer section (20,120) intermediate the first and second ends (14,16a,114,116a),
wherein the outer portion of the pilot section (18,118) is an uninterrupted circular section.

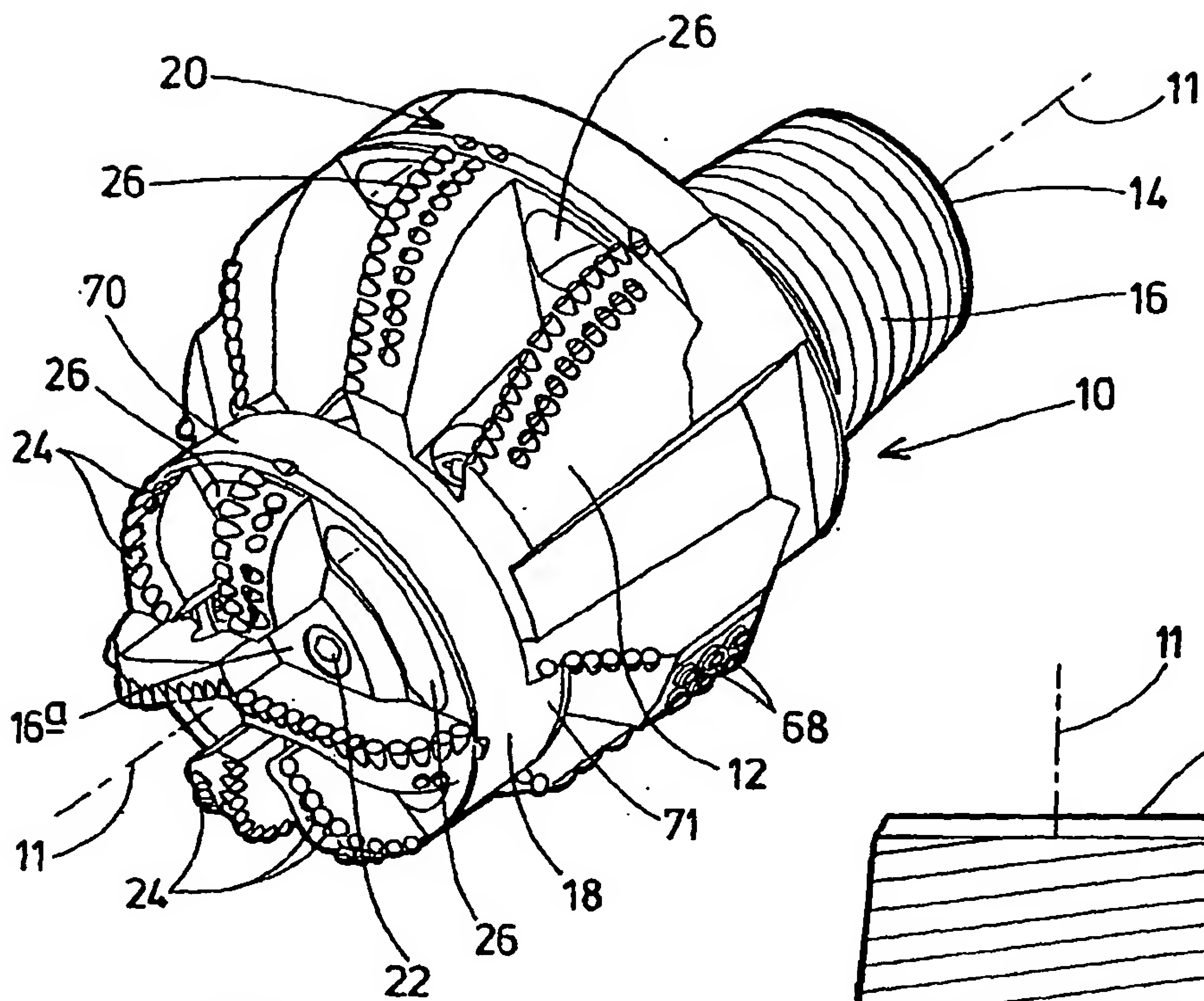
20
26
26
11
14
16
70
26
10
24
16a
68
12
71
11
18
24
22
26

FIG 1

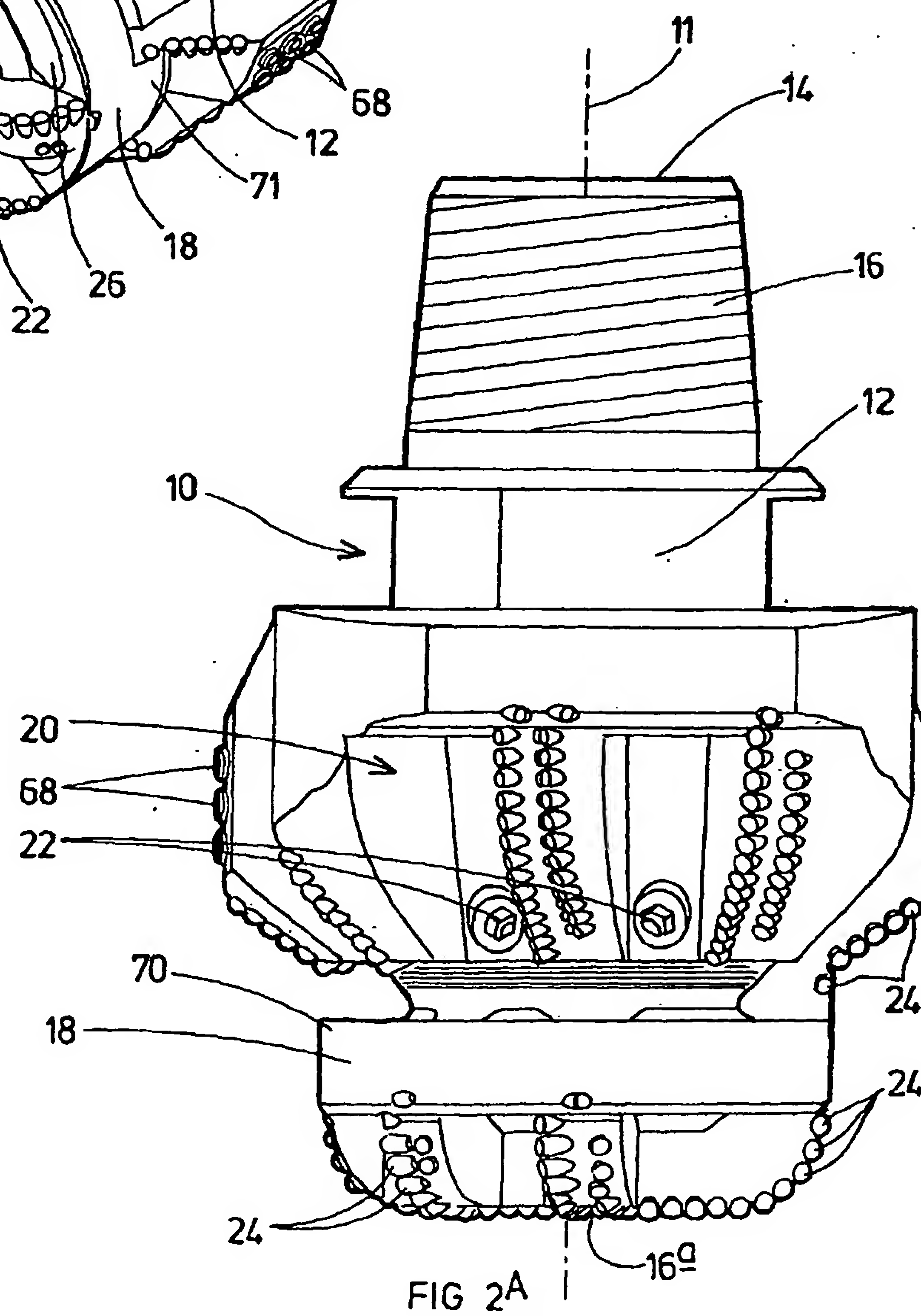
11
14
16
12
10
20
68
22
70
24
18
24
24
16a

FIG 2A

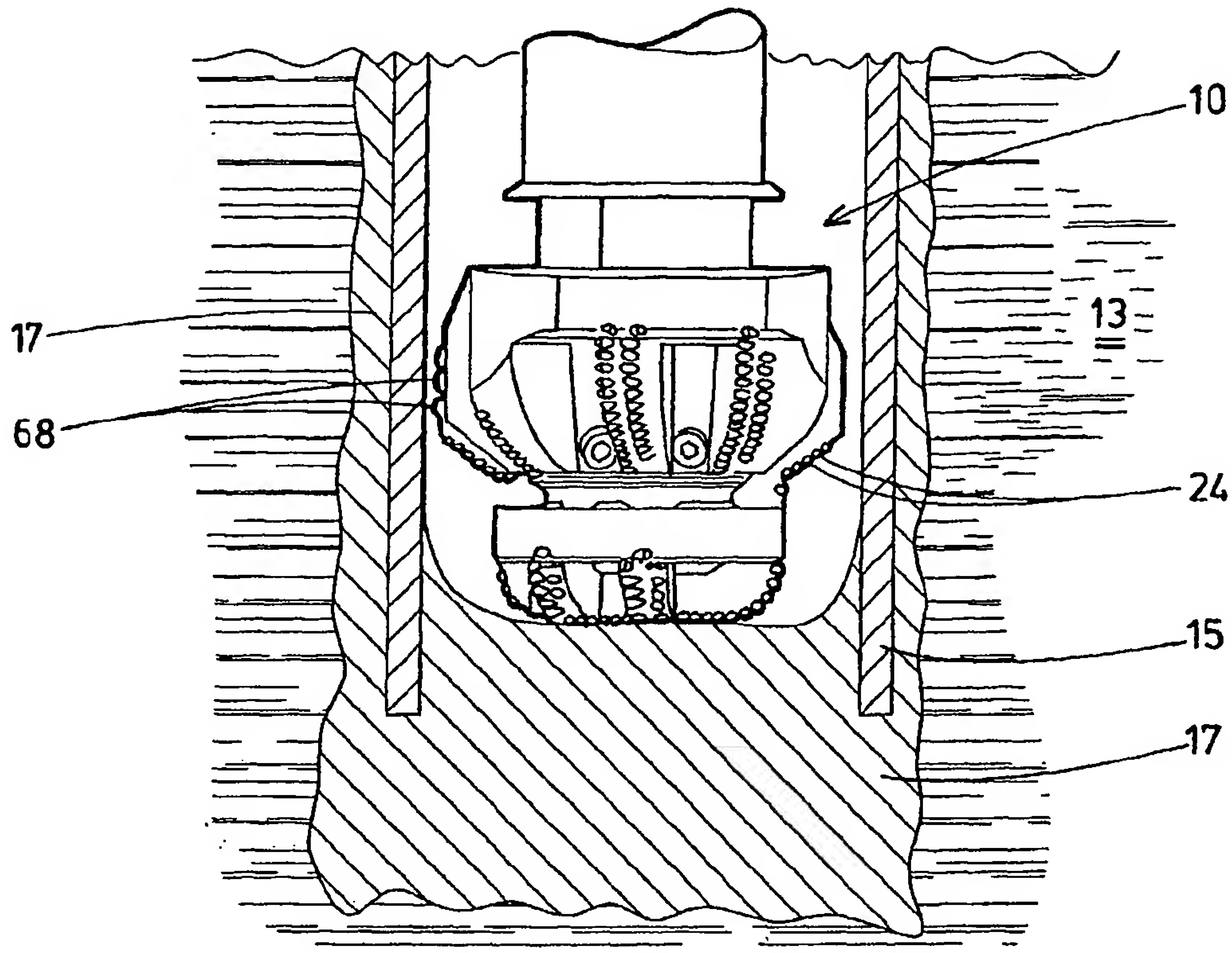

FIG 2B

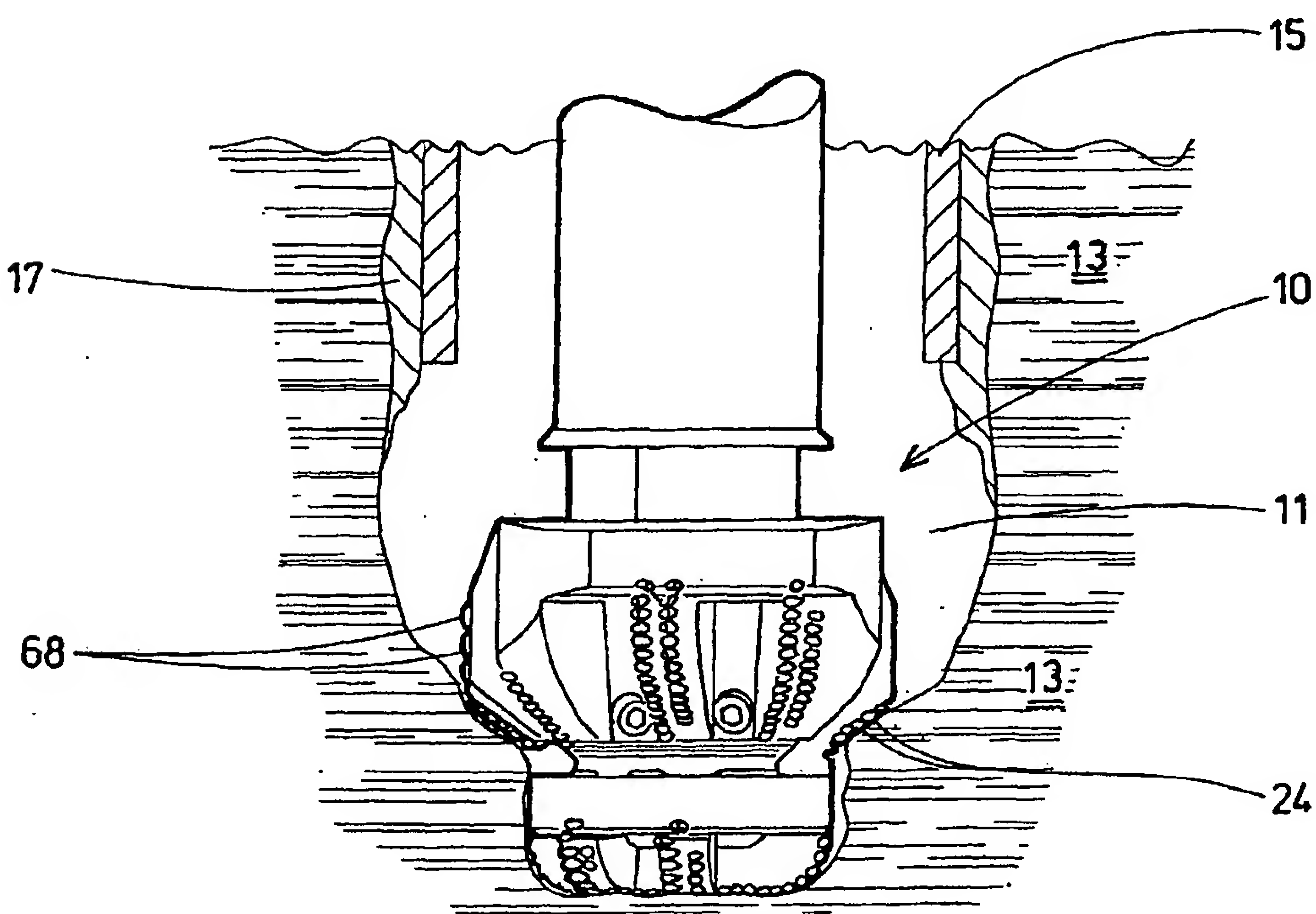

FIG 2C

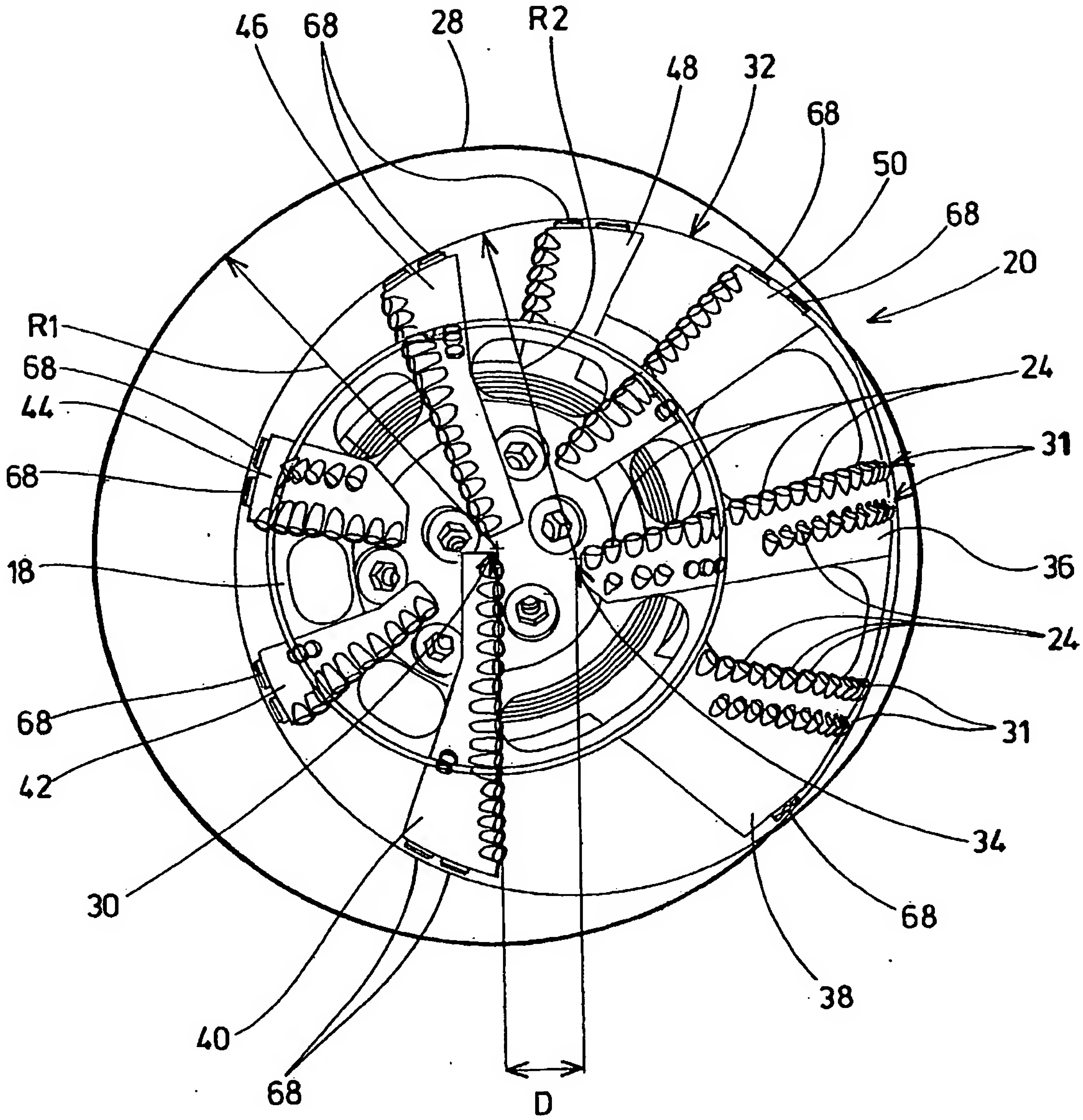
46
68
28
R2
48
32
68
50
68
20
R1
68
44
68
24
31
18
36
24
68
31
42
34
30
68
38
40
68
D

FIG 3

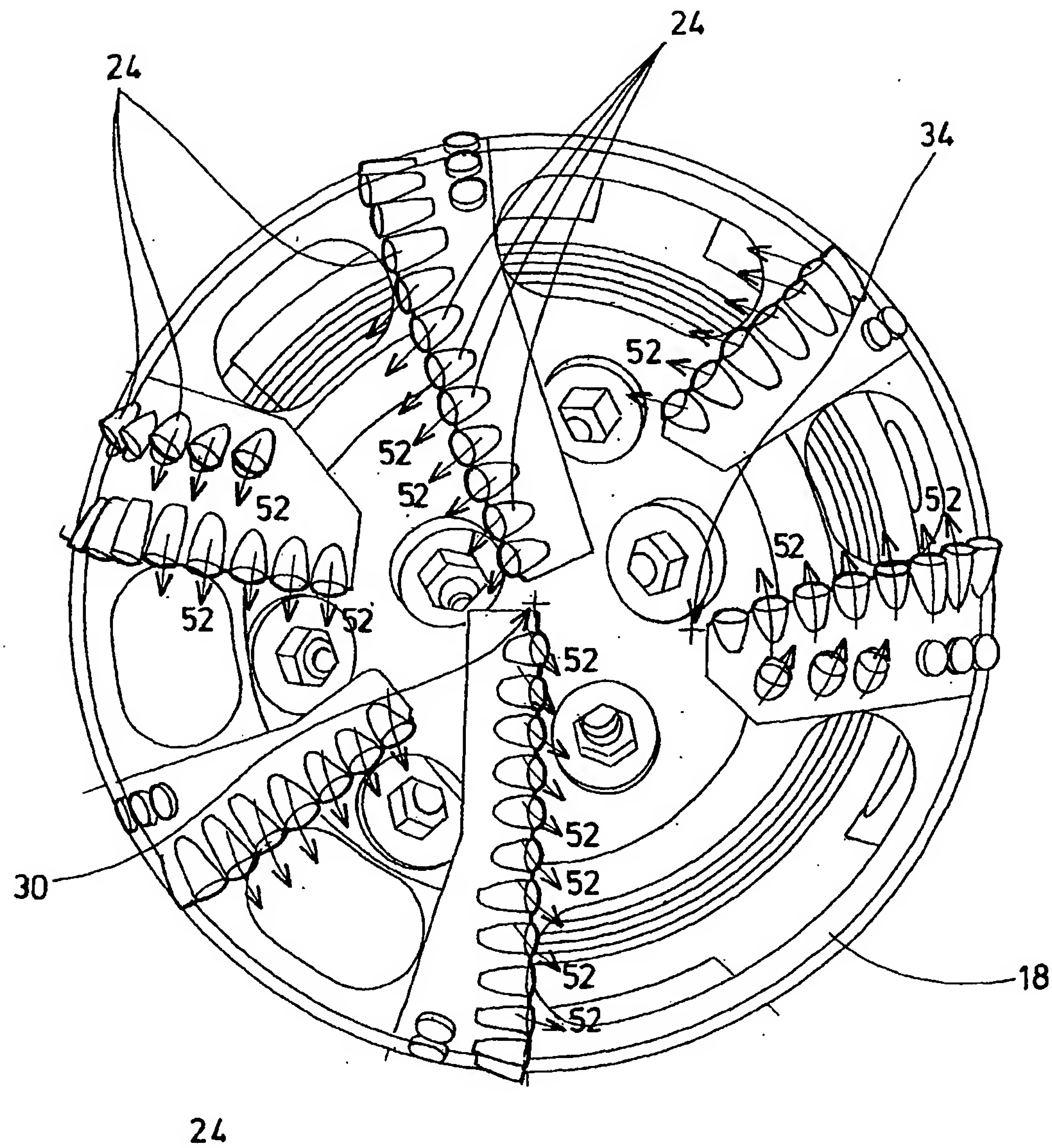

FIG 4

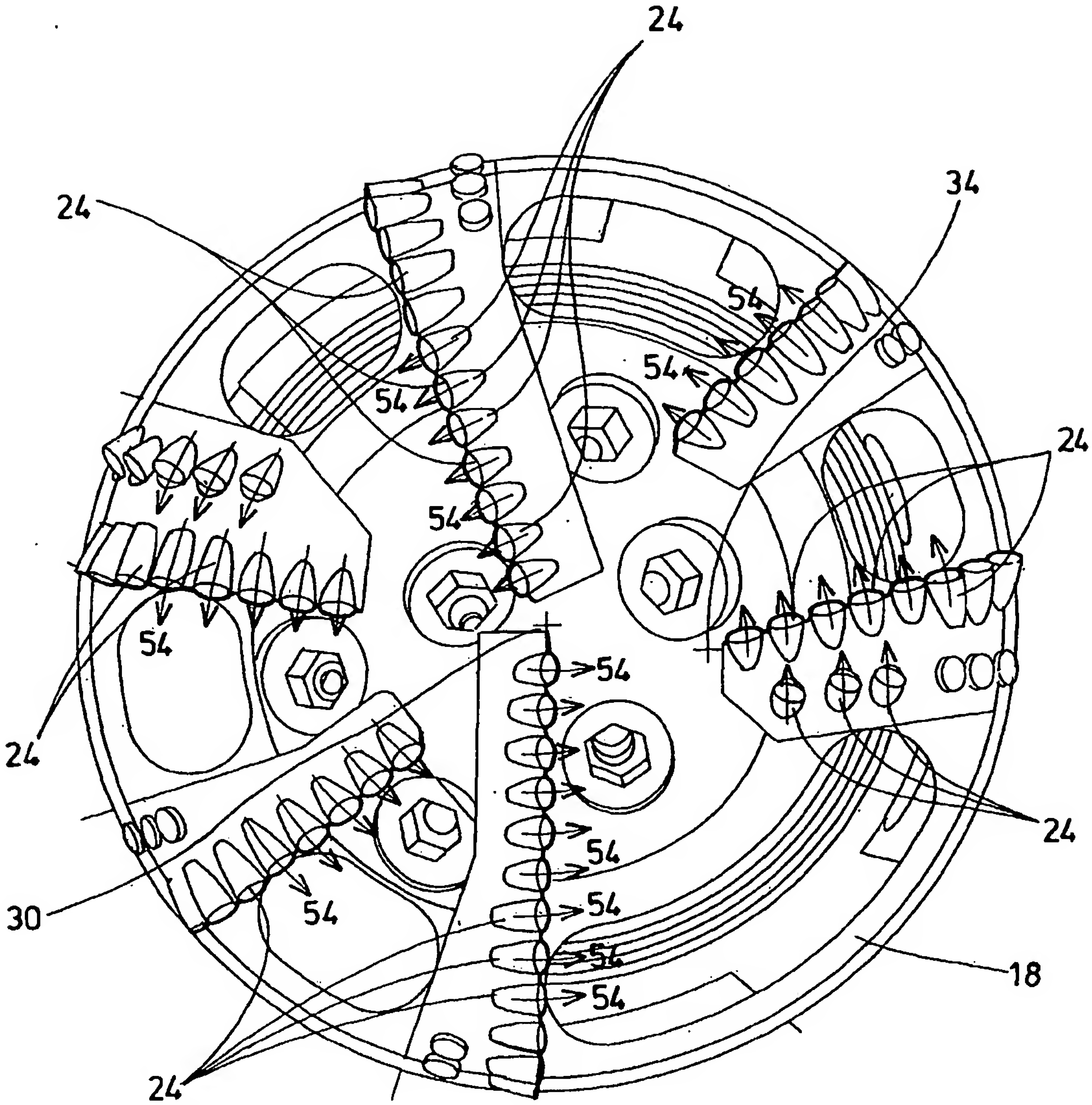

FIG 5

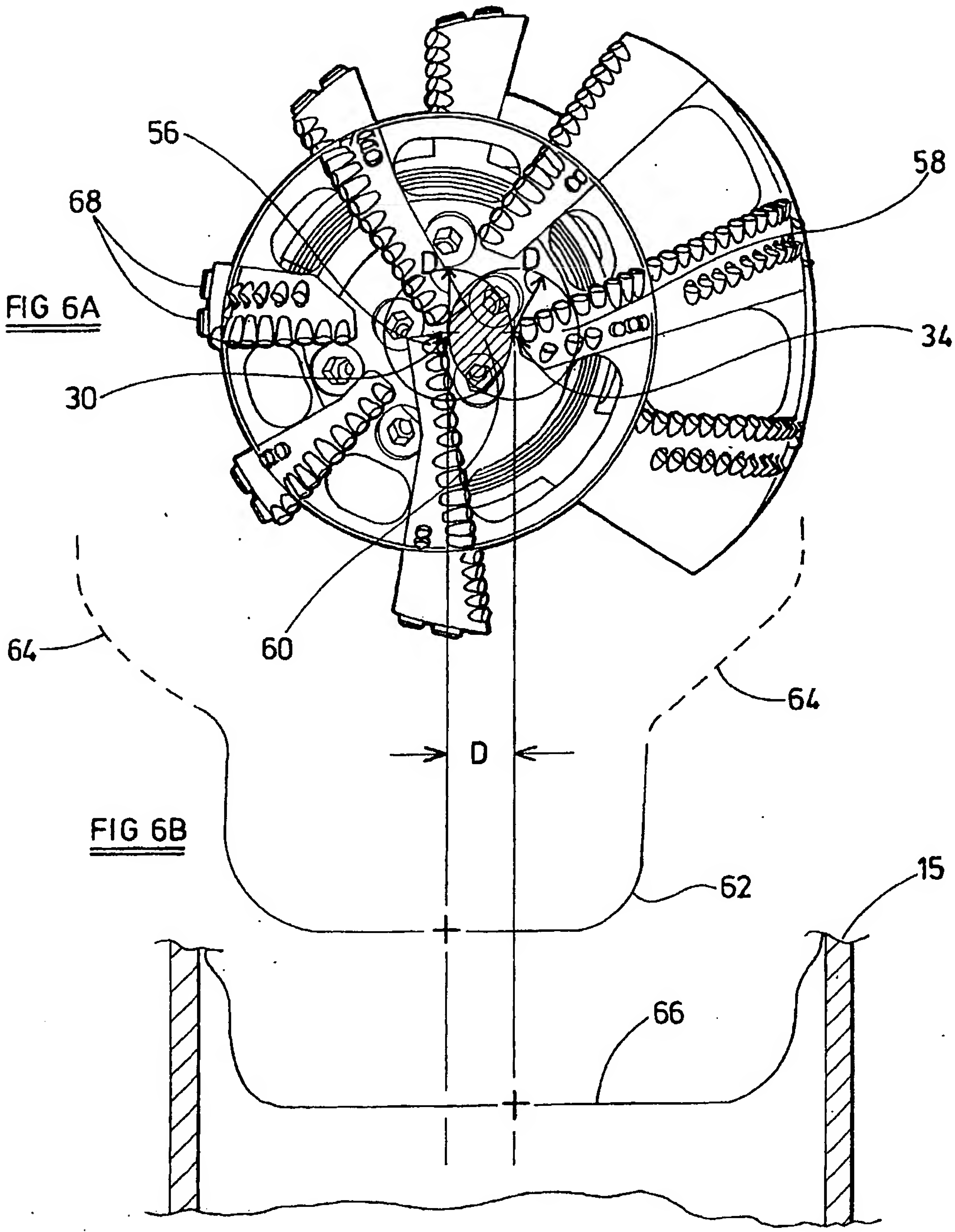

FIG 6A

FIG 6B

FIG 6C

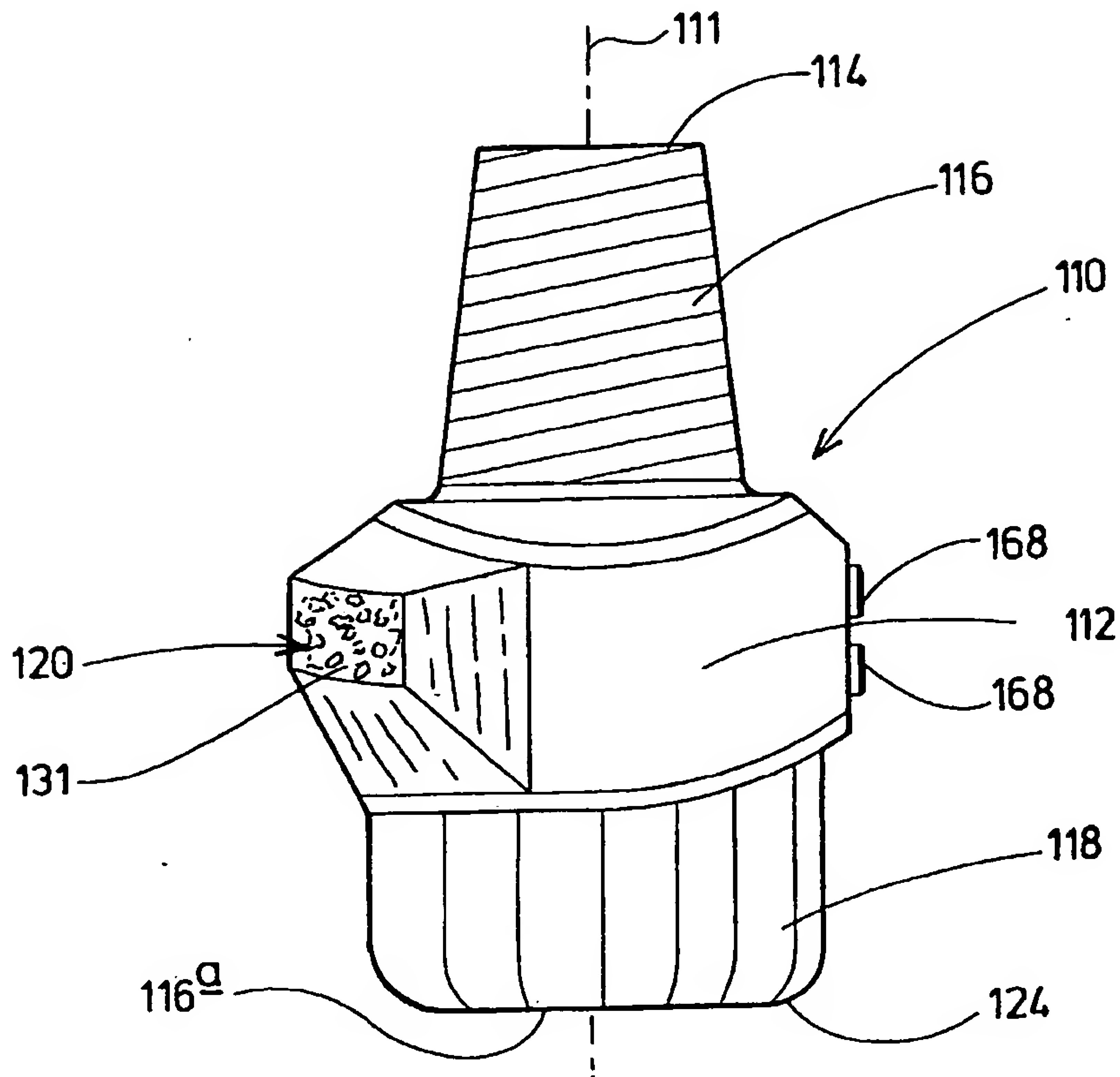
111
114
116
110
168
112
168
120
131
118
116a
124

FIG 7

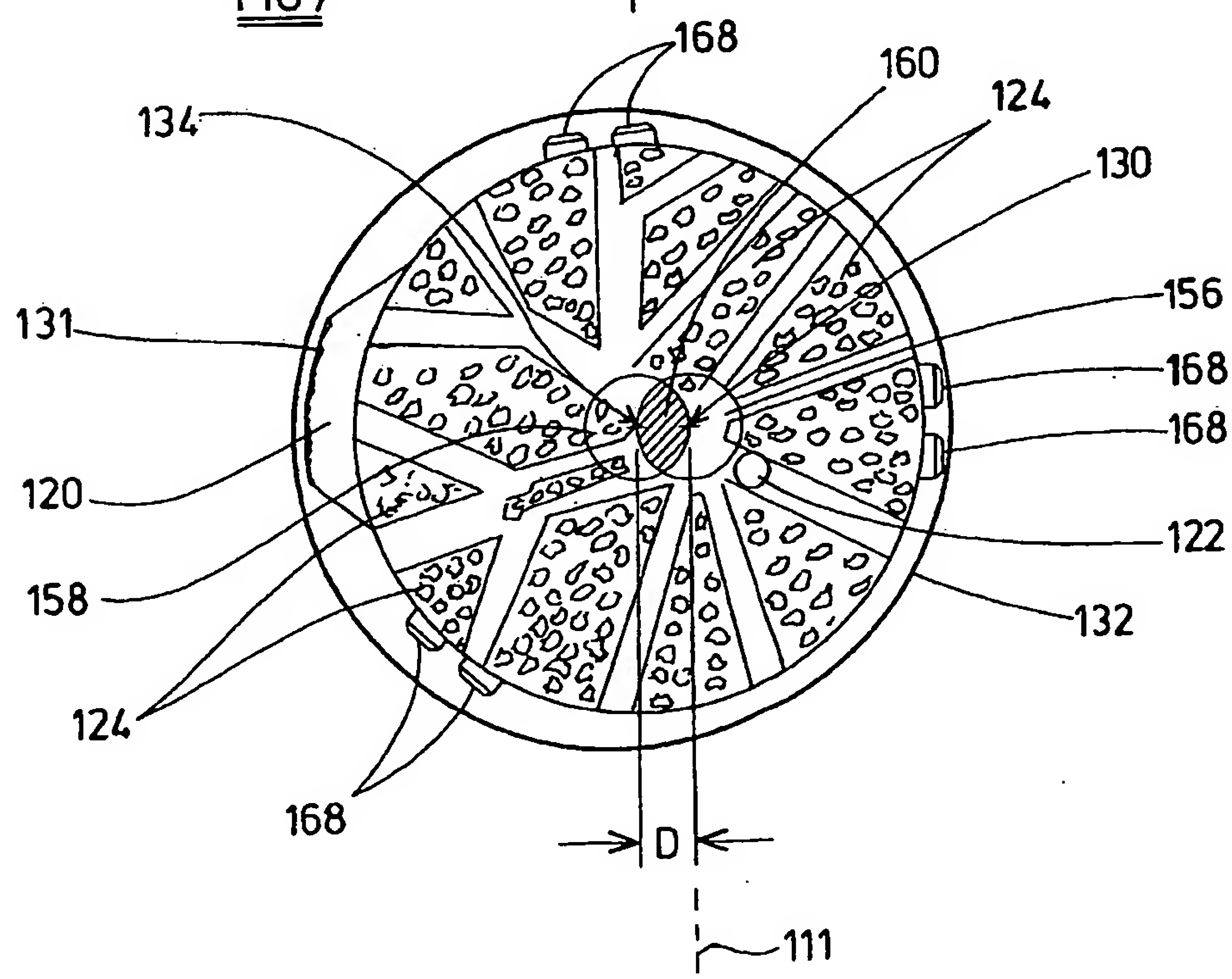
168
160
124
134
130
156
131
168
168
120
122
158
132
124
168
D
111

FIG 8

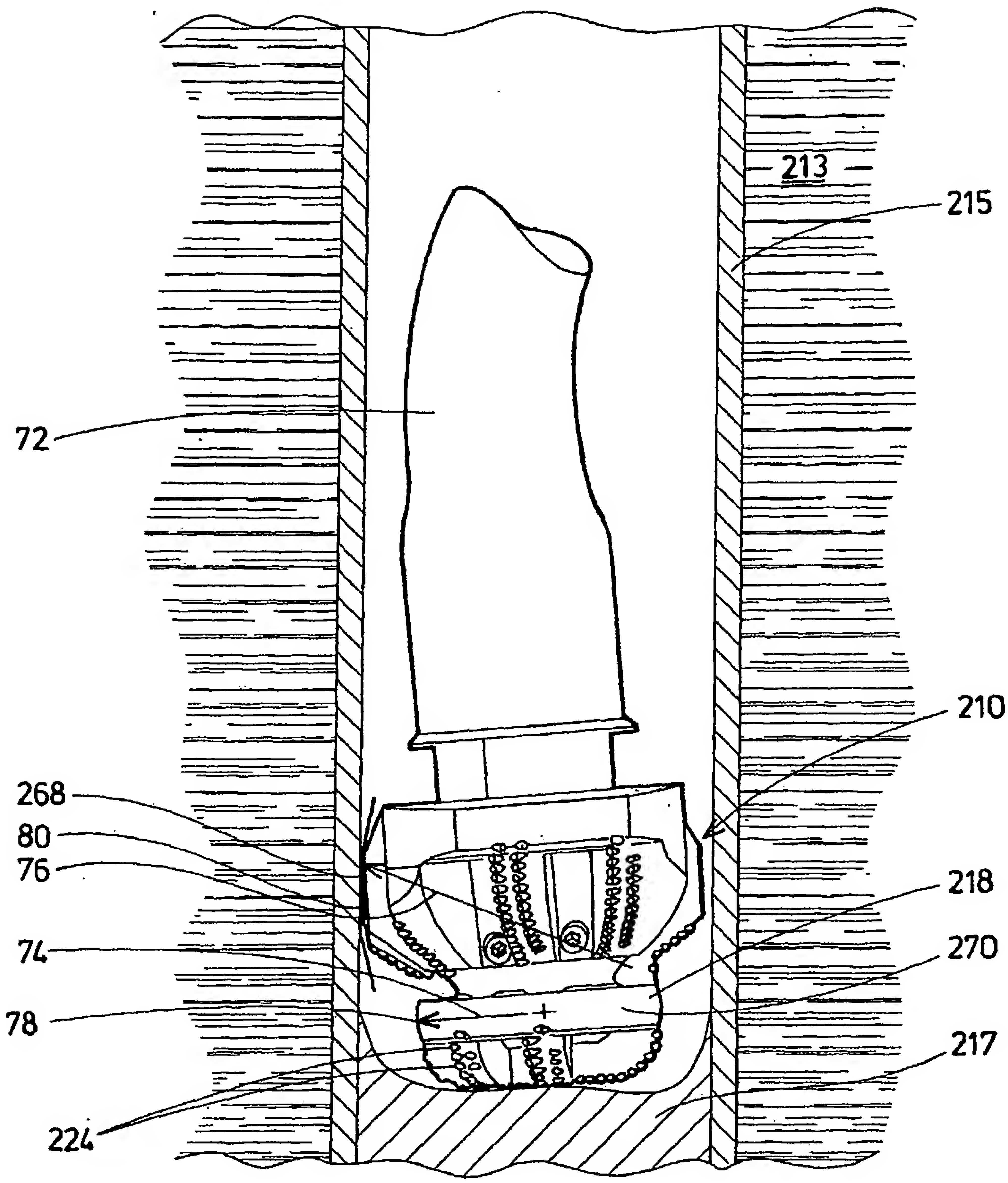

FIG 9

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 01 4475

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	US 5 497 842 A (THAYN COREY S ET AL) 12 March 1996 (1996-03-12) * column 1, line 20 - column 1, line 35; figure 5 *	1	E21B10/26 E21B10/42 E21B7/06
A	US 5 259 469 A (STJERNSTROEM KARL-AXEL ET AL) 9 November 1993 (1993-11-09) * abstract; figures 5,10 *	1	
A	US 4 545 441 A (WILLIAMSON KIRK E) 8 October 1985 (1985-10-08) * column 2, line 55 - column 2, line 68 *	1	
A	GB 2 031 481 A (MARRIOTT R) 23 April 1980 (1980-04-23) * page 3, line 118 - page 4, line 13 *	1	
A	EP 0 391 873 A (UNIROC AB) 10 October 1990 (1990-10-10) * column 2, line 32 - column 2, line 36; figure 6 *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
A	US 5 099 929 A (KEITH CARL W ET AL) 31 March 1992 (1992-03-31) * column 5, line 26 - column 5, line 40 *	2	E21B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	24 September 2002	Morrish, S

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 02 01 4475

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

24-09-2002

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 5497842	A	12-03-1996	NONE		
US 5259469	A	09-11-1993	SE	467632 B	17-08-1992
			AT	108861 T	15-08-1994
			AU	642708 B2	28-10-1993
			AU	7228091 A	05-08-1991
			CA	2074076 A1	18-07-1991
			DE	69102993 D1	25-08-1994
			DE	69102993 T2	02-03-1995
			EP	0511298 A1	04-11-1992
			FI	923240 A ,B,	15-07-1992
			JP	5503556 T	10-06-1993
			NO	922814 A	16-07-1992
			SE	9000156 A	18-07-1991
			WO	9110805 A1	25-07-1991
US 4545441	A	08-10-1985	US	4429755 A	07-02-1984
GB 2031481	A	23-04-1980	NONE		
EP 0391873	A	10-10-1990	SE	501988 C2	10-07-1995
			AT	96883 T	15-11-1993
			DE	69004316 D1	09-12-1993
			DE	69004316 T2	24-03-1994
			EP	0391873 A2	10-10-1990
			ES	2046770 T3	01-02-1994
			SE	8901198 A	06-10-1990
			US	5009274 A	23-04-1991
US 5099929	A	31-03-1992	NONE		

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record.

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- [x] BLACK BORDERS
- [ ] IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- [ ] FADED TEXT OR DRAWING
- [x] BLURRED OR ILLEGIBLE TEXT OR DRAWING
- [ ] SKEWED/SLANTED IMAGES
- [ ] COLOR OR BLACK AND WHITE PHOTOGRAPHS
- [ ] GRAY SCALE DOCUMENTS
- [x] LINES OR MARKS ON ORIGINAL DOCUMENT
- [x] REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- [ ] OTHER: ______________________

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.